INTERNAL AND EXTERNAL LOAD MONITORING: THE SCIENCE AND THE PRACTICE

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Coaches prescribe external workloads to elicit positive training outcomes related to athlete performance, health, and/or risk of injury. These training outcomes are underpinned by functional adaptations which occur because of the psychophysiological response to the external load; this is referred to as the internal load. Tim Roberts, MSc, CSCS, Senior Scientist at the Gatorade Sports Science Institute describes that through training load monitoring and the consequential control of certain athlete behaviors, internal load and therefore training outcomes can be optimized.

DEFINING INTERNAL AND EXTERNAL TRAINING LOAD MONITORING

- Training load is the input variable of the entire training process and has the purpose of eliciting a desired training outcome.
- Internal and external load are the two measurable components of training load.[1,2]
- External load is the prescribed work measured externally to the athlete and measures are specific to the nature of the exercises which make up the training (examples can be found in **Table 1**).
- The organization (frequency, timing, exercise selection, intensity), quantity, and quality of the exercises prescribed by the coach determines the external load.[3]
- Internal load is all the psychophysiological responses that occur during the execution of an external load. It is measured internally to the athlete and measures must be chosen that are valid for the nature of the exercises being completed (examples can be found in **Table 1**).
- The internal training load is what determines the functional adaptations and the change in training outcomes for an individual. Importantly, the internal load can vary between athletes who complete the same external load due to several different factors. Some of these factors like genetics are not able to be controlled, while others can be.
- Behaviors related to these "controllable" factors such as nutrition, hydration, the environment, and sleep, can be influenced with the purpose of optimizing the internal load and therefore training outcomes (see **Figure 1** below).[4]
- Monitoring internal and external load as well as other measures relating to performance, fatigue, or recovery provides coaches and practitioners information which can inform decisions related to training load and other athlete behaviors.

EXTERNAL LOAD MEASURES	INTERNAL LOAD MEASURES	FUNCTIONAL ADAPTATIONS
• Total Distance • Distance at specific speed • Accelerations • Duration of Specific Effort • Metabolic Power • Repetitions • Frequency of repetitions • Volume Load • Work	• Heart Rate • Lactate Concentration • Volume of oxygen uptake • Ventilation • Substrate utilization • RPE • sRPE	• Hypertrophy • Neuromuscular adaptations • ↑ Mitochondrial Density • ↑ Capillary Density • ↑ Oxidative Enzymes • Motor Learning

TABLE 1. Examples of measures of external load, internal load, and of functional adaptations that occur in response to a training load.

PRACTICAL ADVICE FOR TRAINING LOAD MONITORING

- The goal of an applied athlete monitoring strategy is to support the coach:athlete interface through the provision of data that may inform decisions around the optimization of external load prescription and/or other athlete behaviors that might moderate their response to it (see **Figure 1** below).[5]
- When developing an athlete monitoring strategy, appropriate measurement of external load should be the foundation. For a coach to prescribe the optimal external load, they must understand what workload the athlete is currently experiencing both during training and competition.[6]
- The next important component in the practice of athlete monitoring is to appropriately measure the internal load of the athlete as this provides insight into their individual response. The internal load measure(s) should be valid for the exercise mode being completed by the athlete. The use of session rating of perceived exertion (sRPE) may be advantageous to those who work with athletes training in multiple modes of exercise, including resistance exercise.[7]
- Other measures often related to performance, fatigue, or recovery should then be selected based on the contextual information they provide, and the athlete behavior related outcomes from their analysis and interpretation.
- All monitoring practices should be developed relative to the resources available in the unique environment of the scientist/practitioner and it is possible to develop a successful monitoring program with few resources.
- The analysis and interpretation of data should be structured to evaluate the athlete as an individual. Furthermore, when examining the training variability, acute to chronic workload ratios, or other statistical models developed to provide meaningful inferences; the focus should be on simple and scientifically valid reporting.[8]
- Efficient and effective communication within an interdisciplinary team may be the difference between success and failure in an athlete monitoring program.

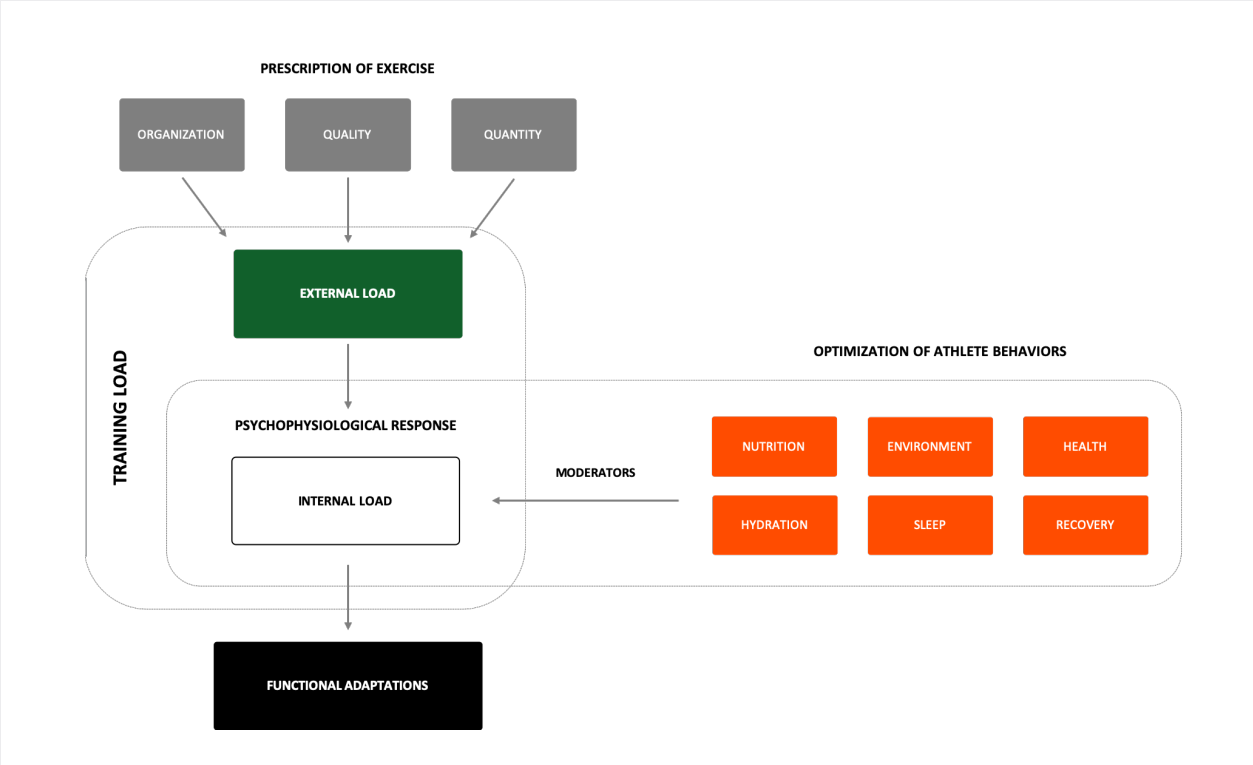

FIGURE 1. A theoretical framework adapted from Impellizzeri et al. 2019[4] depicting how the prescription of external load and the optimization of athlete behaviors moderates internal load and the functional adaptive response. These responses underpin changes in training outcomes related to health, performance, and injury risk.

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